Neurolab

Puzzle of how human nervous system works will be focus of investigations on ambitious marathon mission in April

The pursuit of answers to questions of how the body functions in space is like a search for pieces to a grand puzzle. Many pieces are easily identified and slip readily into place. Others remain elusive.

Occasionally, the placement of a single long-sought piece brings together whole segments, surprising the puzzler with the look of the big picture. And, as the body of knowledge about space life sciences expands, so does the puzzle. The result is an ongoing invitation to continue the search.

Neurolab, the focus of the April flight of *Columbia* on STS-90, is dedicated to the study of the human nervous system. One of the most complex and least understood parts of the body, the nervous system is made up of the brain, spinal cord, peripheral nerves and sensory organs. The nervous system faces major challenges adapting to space flight, as it must adjust to those changing conditions while continuing to control blood pressure, maintain balance, coordinate movements and regulate sleep.

Since Neurolab focuses on basic neuroscience research questions, the mission will provide a unique contribution to the study and treatment of neurological diseases and disorders. While the foremost goal of Neurolab is to expand understanding of how the nervous system develops and functions in space, the research also will increase scientists' knowledge of how this system develops and functions on Earth.

"For NASA, the Neurolab mission, with its domestic and international partners, represents a milestone in the effort to provide scientific researchers with access to space," said Dr. Frank Sulzman, lead scientist for NASA's Life Sciences Division and the originator of the Neurolab Program. "The mission also signifies the achievement of a certain level of maturity in NASA's life sciences research—a point at which we begin using the unique tool of space to conduct sophisticated experiments. On Neurolab, this tool will provide a way of examining the nervous system that is not possible on Earth. The research subject will experience a unique sensory environment, and we will test exciting theories on how the nervous system responds."

Of all the systems in the human body, the nervous system is the most responsive to the environment, recognizing changes immediately and accommodating them readily. This responsiveness, as it occurs in the studies on Neurolab, will offer new views of how the nervous system works both in space and on the Earth. In addition, the results will form a basis for neuroscience to be carried out on the International Space Station.

Space shuttle managers have tentatively set April 16 as the launch date for Neurolab, with liftoff at 1:19 p.m. JSC time.

Commander Rick Searfoss, Pilot Scott Altman, Mission Specialists Rick Linnehan, Dave Williams and Kay Hire, and Payload Specialists Jay Buckey and Jim Pawelczyk are scheduled to head for Kennedy Space Center and a final dress rehearsal of launch procedures Tuesday. The seven will serve as both subjects and operators of the experiments, using a wide array of biomedical instrumentation, including some instruments and devices developed especially for this mission.

Neurolab also will carry rats, mice, two kinds of fish, snails and crickets into space for its complement of experiments. The investigations, subjects and associated hardware will be housed in a Spacelab module and the shuttle middeck. Experiments will study the adaptation of the vestibular system and space adaptation syndrome, the adaptation of the central nervous system and the pathways which control the ability to sense location in the absence of gravity, and the effect of microgravity on a developing nervous system. To support more than two weeks of research, the shuttle will be configured with the Extended Duration Orbiter System.

As a result of the data collected over the years on how astronauts adapt to microgravity, researchers are beginning to understand the basics of space physiology. Each piece added to the space life sciences puzzle, however, presents more questions to be answered.

For example, although our basic movements such as walking and balancing were learned with gravity present, how can humans adapt so quickly to function without gravity? How do gravity-sensitive parts of the body such as the inner ear, cardiovascular system and muscles learn to cope without gravity? Why do sleep and biological rhythms change in space? Will inner ears that developed in space function the same as those that developed on Earth?

These questions may be answered by taking measurements of the crew and research animals before, during and after the flight. The experiments have been grouped into eight disciplines. JSC is managing the four human experiment teams—Autonomic Nervous System, Sensory Motor and Performance, Vestibular and Sleep—and a combined total of 11 experiments that will use crew members as subjects. Ames Research Center is managing the four non-human experiment teams—Neuronal Plasticity, Mammalian Development, Aquatic and Neurobiology—with 15 experiments that will study research animals.

Sensory Motor and Performance Team

On Earth, when humans make simple, everyday movements such as pointing or catching a ball, the nervous system takes gravity into account. The brain integrates information from the eyes and inner ear, as well as from nerves in the joints and muscles, to make smooth, accurate movements.

In space, however, the inner ear no longer provides the brain with useful information about "up" or "down" and the nerves in the joints are sensing the movements in weightless limbs.

This means the nervous system must be adapting so astronauts can function effectively. The members of the Sensory Motor and Performance Team want to measure this adaptation and understand how it takes place. They will use a variety of novel techniques to do so on Neurolab.

Using a simple, but effective ball-catching experiment and a Kinelite test apparatus developed by the French Space Agency, scientists will study the ability of the central nervous system to accept and interpret new stimuli while the body is in space.

Another experiment will look at how microgravity alters simple eye-hand coordinated movements like grasping or pointing using the Visuo-Motor Coordination Facility, developed by the Canadian Space Agency.

Yet another experiment will use virtual reality to discovery how the body shifts emphasis from inner ear cues to visual cues. The tests will use NASA's Virtual Environment Generator, a head-mounted display, to show computer-generated scenes and track the motion of the head.

Results from the Sensory Motor and Performance experiments are expected to add insight into how the nervous system can find a new balance between information it gathers from the eyes, inner ear and joints that could help in the design of spacecraft and testing patients with neurological diseases.

Autonomic Nervous System Team

The Autonomic Nervous System Team on Neurolab wants to uncover what changes in blood pressure control during space flight lead to the balance problems astronauts encounter after flight.

The symptoms are similar to those experienced when an elderly man stands up quickly after awakening or a fighter pilot forces his plane into a tight turn—they feel dizzy and fall or nearly pass out. In both cases, the cardiovascular system is stressed by gravity, a condition called orthostatic intolerance.

While the autonomic nervous system controls many other functions beside blood pressure, on Neurolab the control of blood pressure is the major focus. To regulate blood pressure, the body has two main tools. It can change the amount of blood flowing by increasing or decreasing the pumping action of the heart, or it can change the resistance to blood lowing in the blood vessels.

On Neurolab, crew members will carry out a comprehensive set of tests designed to investigate every aspect of autonomic circulatory control, with the overall goal of understanding how it has changed during space flight.

In addition to blood pressure and other basic cardiovascular parameters, blood flow to the brain will be estimated using high-frequency sound waves. Researchers also will monitor nerve signals traveling from the brain to the blood vessels using a small acupuncture-like needle inserted just below the knee.

These measurements will be made while the nervous system is challenged by a variety of tests. One test stimulates pressure receptors in the neck and chest and measures the responses. Another uses the lower body negative pressure test to place stress on the cardiovascular system similar to that experienced in Earth's gravity.

Taken together, this comprehensive set of measurements should help to solve the puzzle of why astronauts have problems with blood pressure control after space flight, and may also allow doctors to help the 500,000 Americans who suffer from similar symptoms.

Data from Neurolab may provide insight into orthostatic intolerance syndromes such as orthostatic tachycardia and help develop countermeasures.